Acoustic Emission In-service Detection of Cryogenic Storage Tank Floors

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Abstract

This paper explores AE in-service testing of cryogenic storage tank floors of monolayer or bi-layer (dual tanks) by means of recommended methods of sensor coupling and mounting. For AE inspection of monolayer tanks, we tried to use water instead of ordinary couplant such as vacuum grease, which is unsuitable to couple sensors because of its high sound attenuation in cryogenic temperatures, and we got ideal results. As for cryogenic bi-layer tanks, it is hard to fix sensors directly to the shell of inner tank to collect signals from the floor, we found that sensors can be placed on protruded ends of braces connected to inner tank shell. An example of AE in-service testing of a cryogenic bi-layer tank floors is given and significative experience is achieved.

Keywords: AE in-service testing, cryogenic storage tank floors, coupling, bi-layer tanks

0 Introduction

AE online inspection of vertical atmospheric tanks can offer owners the priority sequence of maintenance. Based on AE testing results, the safety levels of all tanks inspected can be graded to A to E. In most cases, more than 50% of storage tanks are unnecessary to shutdown for immediate maintenance, and these tanks can continue to run several years, only less than 20% of them need to shutdown for further examination and repair. AE testing of tanks can offer considerable financial, safety and environmental benefits by providing information on tank integrity without draining or incurring extensive down time, and generally only the areas with problems need to be maintained, thereby minimizing costs. Otherwise, opening a tank for inspection and repair introduces oxygen into the tank, the corrosion process starts all over again when it is put back into service. Therefore, AE testing has many benefits such as on-line testing, global monitoring, rapid inspection, and cost reduction. However, applications of testing atmospheric tanks with AE are not so successful compared to AE testing of pressure vessels because of the shorter history of AE application on tank floors, relative immature mechanism or theory of acoustic emission sources, and other difficulties, i.e. they generally have larger diameters (up to 100 meters and over), loading conditions are limited and the floors are inaccessible, and false source locations and lost source locations are easy to occur. Sensors with lower frequencies have to be adopted to acquire data from floors

to minimize the propagation attenuation because of longer sensor spacing, even if more noises are easy to interfuse into “useful” signals, which make the interpretation of testing data and the integrity assessment of tank floors more difficult. Furthermore, the selection of effective sensor coupling modes is another problem of cryogenic storage tanks with insulation in that ordinary couplants generally are unsuitable to couple sensors because of their high sound attenuation in cryogenic temperatures. As for cryogenic bi-layer tanks, the inner tank is inaccessible, so it is hard to fix sensors directly to the shell of inner tank to collect signals from the floor. This paper will discuss these issues and give some recommended practices. [1-4]

1 AE in-service Testing of Cryogenic Storage Tank Floors of Monolayer

Generally, based on tank diameter and impurity sediment of medium, a quantity of small holes with 200-250mm diameter and 0.3-1.0m apart from tank floor plate can be opened in the insulation of tank cylinder for sensor mounting. The testing procedures of them are same to that of tanks in normal temperatures. In cryogenic temperatures, one problem is if sensors may produce electronic noises, another is how to choose a suitable couplant with lower attention. We think that sensors with pre-amplifier integrated should not be used because more self-excited electronic noises may be induced.

To find a simple and valid sensor coupling technique, we tested the coupling effectiveness of vacuum grease (as a common couplant) and water/ice in cryogenic temperatures, and made a comparison with that of vacuum grease in normal temperature. The testing was conducted by means of sensors R15-AST, R3I-AST, and Acoustic Emission Station of PAC, USA. Using pencil break of Φ0.5mm, HB in a place of 100mm apart form sensors as the simulation source and considering the means of responding amplitudes of 10 simulated signals, We found that the average amplitude response of water/ice as the couplant in cryogenic temperature is nearly the same as that of using vacuum grease in normal temperature, but when using vacuum grease instead of water/ice in cryogenic temperatures, the effectiveness will be deteriorated and more than 10dB of the mean amplitude response will be reduced. Therefore, we think that using water/ice as the couplant in cryogenic temperature is a simple economical and effective practice in AE testing of tanks. Before testing, a couple of drops of water can be dropped on the sensor surface and then put it on the polished shell wall for a few seconds until a thin layer of ice is formed between sensor surface and tank wall , a special clamp can be used for further fixation.

Waveguides can be used to AE testing of cryogenic storage tanks, but in most cases they can not be adopted because of easy cracking when welded them to tank walls in service conditions, which will severely damage tanks, unless they are welded to tank walls during their construction or former shutdowns.

2 AE In-service Testing of Cryogenic Storage Tank Floors of bi-layer

A cryogenic bi-layer tank consists of an inner tank for storing medium and an outer tank for insulation. Generally, granular insulation and some inert gas such as nitrogen are filled in the space between the shells of inner tank and outer tank, a rigid insulation is located between two floors. The inner tank is inaccessible and there is scarcely any metallic connection between two shells, so it is hard to mount sensors directly to the shell of inner tank to collect

signals from the floor. By viewing the construction drawings of this kind of tanks and observing them in field, we found that mounting sensors on protruded ends of braces from inner tank shell may be a good and the only choice for AE in-service testing of a cryogenic bi-layer tank floors. Obviously, longer braces and their longer distances from brace-shell connections to inner tank floor are disadvantageous for signal propagation, but there is no other choice.

3 A Example of AE In-service Testing of A Cryogenic bi-layer Tank Floor

We test the floor of an ammonia tank (22m diameter, 8000m^3) in service with 12 AE R30I-AST sensors (Acoustic Emission Station, PAC, USA) mounted on protruded ends of braces from inner tank shell. A brace is 2770 mm long and the distance from brace-shell connection to inner tank floor is 1310 mm, as is shown in figure 1.

To verify the validity of signal transmitting, we hit valves in inlet and outlet pipes with a metallic rod, and to calibrate the sensitivity of sensor coupling, we conducted pencil break tests. The fluid level in the tank was increased to 15m for inspection, which is the highest level can be reached. The test results are shown as in figure 2 and figure 3, which indicated that this practice is feasible.

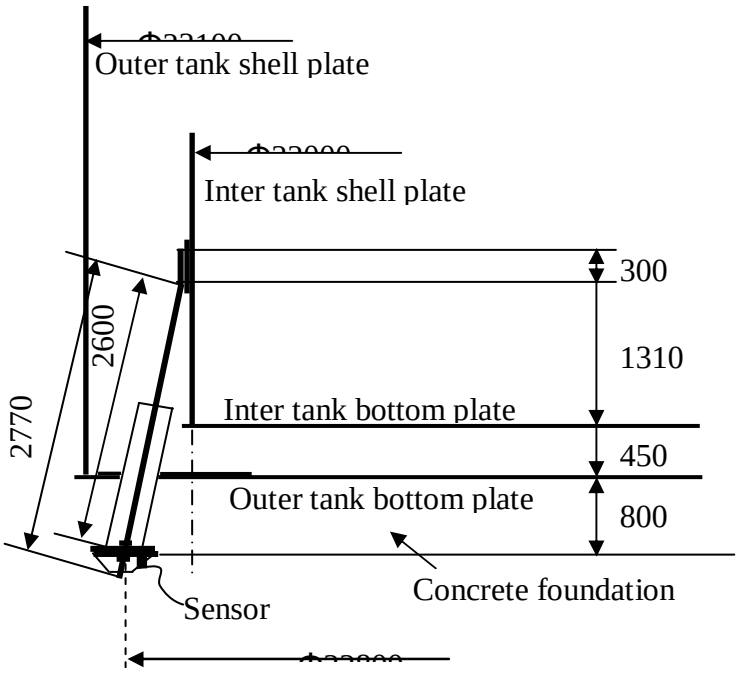

Figure 1. Structure and sensor-mounting places of a bilayer tank

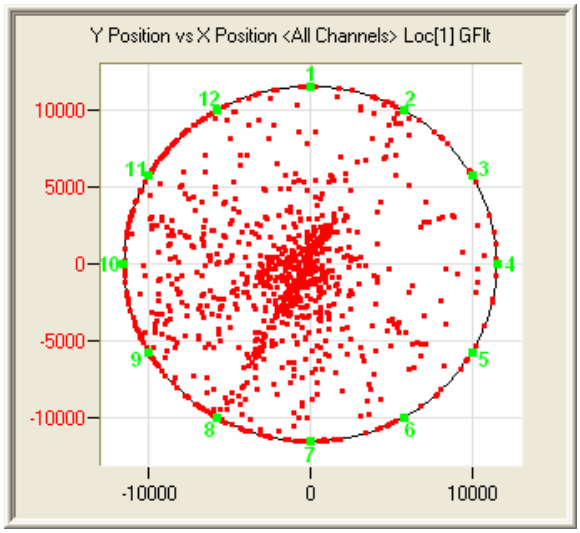

Figure 2. Planar source locations of a bilayer tank

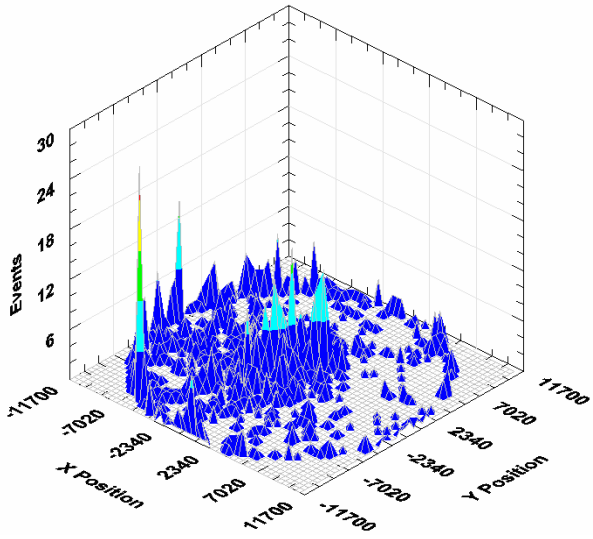

Figure 3. Three-dimensional source locations of a bilayer tank

4 Conclusions

As an economical and convenient couplant used in AE testing of cryogenic tanks, water/ice is a good choice when waveguides can not be adopted because of welding difficulty or cost consideration. AE testing of cryogenic bi-layer tanks by means of braces is acceptable and can offer us indicative results.

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